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PLC Based PV Module Tracking with Microcontroller Backup

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ABSTRACT: The solar PV is an exciting technology but suffers from low efficiency due to inaccurate tracking systems. This paper is an effort to build a solar tracking system using a PLC with position control algorithm and real time clock. Actual voltage generated by the solar panel is compared with a reference voltage. Stepper motor driven Solar panel-motion is proportional to the error voltage. This whole system is controlled and monitored by the PLC and it can be accessed by Android Application anywhere through Internet and WLAN. Stepper motor driver circuits can also be controlled by a microcontroller. In case of PLC failure, the microcontroller is used for backup. Weather changes are monitored by a temperature sensor. The PLC changes the mode of movement by altitude and azimuth angle if the weather is bad.

KEYWORDS: Solar panel tracking, PLC.

I.INTRODUCTION

The increasing demand for electricity necessitates the development of methods to improve the efficiency of power generation units that utilize renewal resources. The sun is one such highly reliable source of electrical energy. The output of the solar panels directly depends on the amount of light they gather which in turn is influenced by the position of the panel with respect to the sun. If a fixed panel with flat surface is used, the light waves from the sun are almost parallel to the surface of the panel in the morning and evening. Hence, the power produced by the panel at those times is nearly zero [3]. As the day progresses, there is a steady increase in power until a point at which the light incident on the panel is perpendicular to the panel surface. Thus, it can be inferred that the angle of incidence should be maintained as close to zero as possible to maximize the output of the panel. This can be done by tilting the panel as required throughout the day.
The system used for this purpose in called a solar tracker. The solar tracker tries to navigate to the best angle of exposure of the light from the sun.

There are 2 types of trackers, namely, single axis tracker and dual axis tracker. Single axis trackers have one degree of freedom that acts as an axis of rotation. Dual axis trackers have two degrees of freedom that act as axes of rotation. Dual axis trackers allow for optimum solar energy levels due to their ability to follow the sun vertically and horizontally.

Fig 1: Figure representing single axis tracking of solar panel.

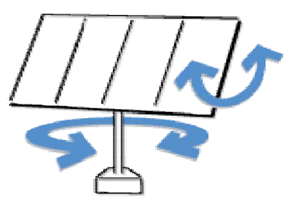

Fig 2: Figure representing dual axis tracking of solar panel

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II. SCHEMATIC REPRESENTATION OF PLC BASED PV MODULE TRACKING WITH MICROCONTROLLER BACKUP

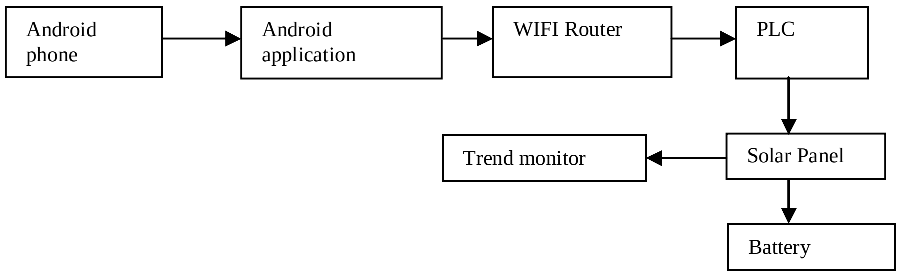

Fig 3: Block diagram representing the proposed system

The solar panel can be monitored using an android phone through an application. The phone and the PLC are connected using a WIFI router. This arrangement also allows for the repositioning of the panel if required.

III. FLOW CHART

The following is a simple flow chart representing the functioning of the system.

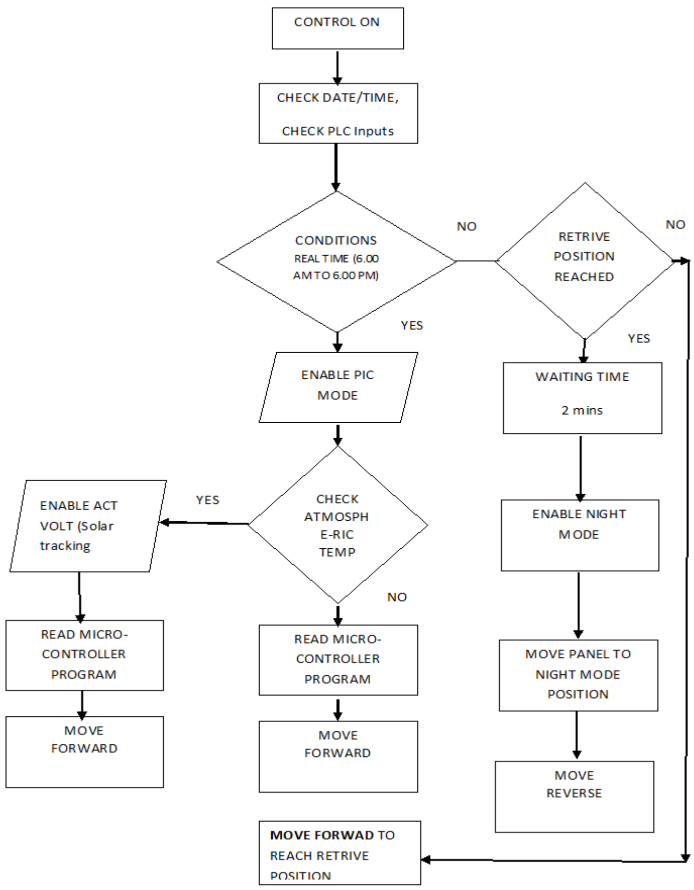

Fig 4: Flow chart representing the system

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The above figure represents the functioning of the system in the form of a flow chart. The mode in which the system has to run is decided based on the current time of the day, output voltage obtained and the ambient temperature by the PLC. The system starts in track mode in the morning. The actions that have to follow depend on the conditions as determined in this mode.

IV. SIMULATION AND EXPECTED RESULTS

The sun tracking system is designed to track the sun in the sky. The real time is fed as input to the algorithm which determines the angle through which the panels have to be rotated. The results of the operations by the PLC, i.e. is the steps through which the motors have to be rotated is fed to the motor drivers. Thus the motors rotate fixing the panels at the desired position. The real time is used by the PLC continuously. Hence, the positioning operation continues throughout the day. This helps in maintaining the angle of incidence of the solar radiation on the panel as close as possible to zero degree. So the power produced by the panel is maximized.

In other words, this tracking mechanism is based on the angle of rotation of earth around its own axis. The time for rotation of earth around its own axis is 24 hours which is equal to the tracking time of this system. This system is always in synchronization with the rotation of earth without any extra component because this system starts at the time of sunrise and goes on as earth rotates on its own axis. This is the reason why this tracking system does not require any sensor or extra component for synchronization.

Weather conditions are monitored by temperature sensors. When the weather is bad, the PLC changes the mode of movement by altitude and azimuth angle.

In order to improve the reliability of the system, microcontroller is used as a backup provision. In case of PLC failure, the microcontroller is used to control the position of the panel until the PLC is ready. The panels can also be repositioned manually if the microcontroller also fails before the PLC is back in operation. Practically, such situations are very rare though. The use of SCADA or HMI also provides options for remote control of the system. Android applications to do the same can also be developed. The mechanical structure of the system can also be similar to that stated in [2].

Hours	Static Panel			Solar Tracking (Single Axis)		
	V	mA	mW	V	mA	mW
08.00 AM	08.4	0.60	05.04	09.15	1.70	15.60
09.00 AM	08.5	1.17	09.94	09.45	1.78	16.86
10.00 AM	08.6	1.25	10.75	09.70	1.99	19.30
11.00 AM	09.7	1.82	17.65	09.85	2.38	23.44
12.00 PM	09.9	2.22	21.97	10.20	2.70	27.54
01.00 PM	10.3	2.56	26.36	10.80	3.20	34.29
02.00 PM	10.5	2.97	31.18	10.70	3.05	32.68
03.00 PM	09.7	2.71	26.28	10.25	2.93	30.08
04.00 PM	08.6	2.50	21.5	09.80	2.63	25.77
05.00 PM	08.3	2.14	17.76	09.25	2.43	22.47
06.00 PM	08.1	1.43	11.58	08.75	1.87	16.40
Average Power			18.18			24.03

Table 1: Simulation results of fixed panels and panels with tracking system (on a cloudy day).

It is expected that the proposed tracking system would increase the efficiency of the panels by 35% on an average and that it would be more useful when the solar panels designed for higher power output than the PV panels come into commercial use.

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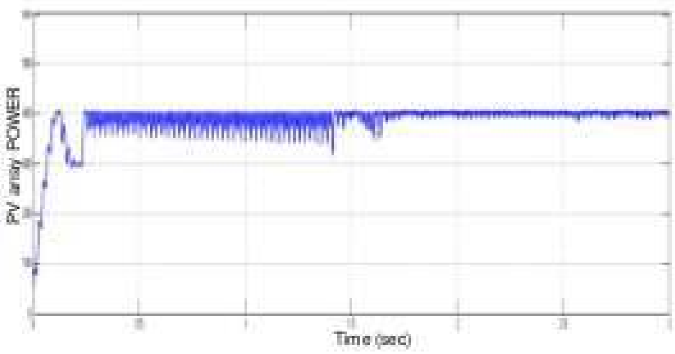

Fig 5: Output power Vs time curve of the PV panel

V. HARDWARE IMPLEMENTATION

The hardware of the system consists of three sub-circuits:
i. The solar panel, the stepper motor and its driver circuit.
ii. The PLC-stepper motor driver circuit.
iii. The microcontroller-stepper motor driver circuit.
iv. The power supply circuit.

i. The solar panel, the stepper motor and its driver circuit: This sub-circuit consists of the stepper motor that is mechanically connected to the panel through gear and shaft and the driver circuit of the stepper motor.

ii. The PLC- stepper motor driver circuit: The output of the computations done by the PLC, i.e., the steps through which the motor is to rotate is fed to the motor through the driver circuit. The driver circuit consists of 4 MOSFETs connected as shown.

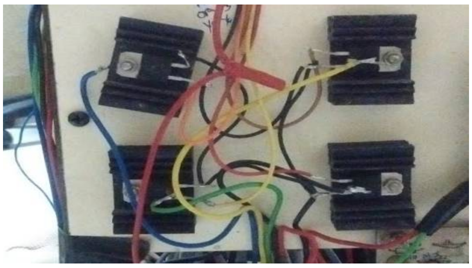

Fig 6: The stepper motor driver circuit.

iii. The microcontroller-motor driver circuit: The motor driver circuit can also be connected to the microcontroller as shown.

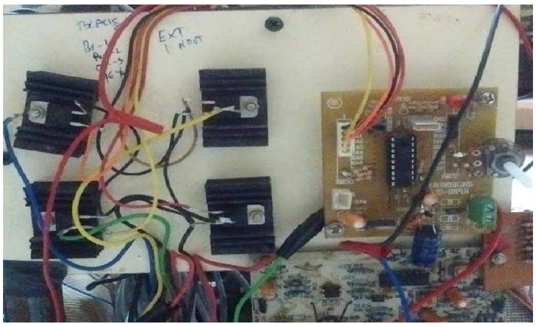

Fig 7: The microcontroller-stepper motor driver circuit

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iv. *The power supply circuit:*This represents the circuit through which the power is supplied to the load. It may consist of various inverters, voltage boosters transformers etc. depending on the nature of load fed. In the presented model, this is represented by a circuit to boost the voltage output of the panel (approximately 12 V) to approximately 24 V to charge a 24 V battery. This battery is also used for the driver circuit.

VI. RESULTS

The following graph depicts the result that was obtained when the project was tested in real time.

Fig 8: Solar Panel Output voltage Vs time graph

VII. CONCLUSION

The objective of this paper is to enhance the efficiency of Photovoltaic panel. Thus, it can be concluded that though the initial investment required for the project is high, it is maintenance free and can surely produce electrical energy free of cost later on.Future scope of this project is that the nearly fail proof tracking system can be implemented to direct the panels precisely towards the sun and hence improve their output voltage.

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